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Mechanical Analysis and Some Physical Properties Of Gray Prairie and Gray Timber Soils of the Lower Illinois Glaciation

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MECHANICAL ANALYSES AND SOME PHYSICAL PROPERTIES OF GRAY PRAIRIE AND GRAY TIMBER SOILS OF THE LOWER ILLINOIS GLACIATION

BY

CLARENCE A. BRADEN

Thesis for the Degree of Bachelor of Science
in Agronomy

COLLEGE OF AGRICULTURE
UNIVERSITY OF ILLINOIS

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IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF BACHELOR OF SCIENCE

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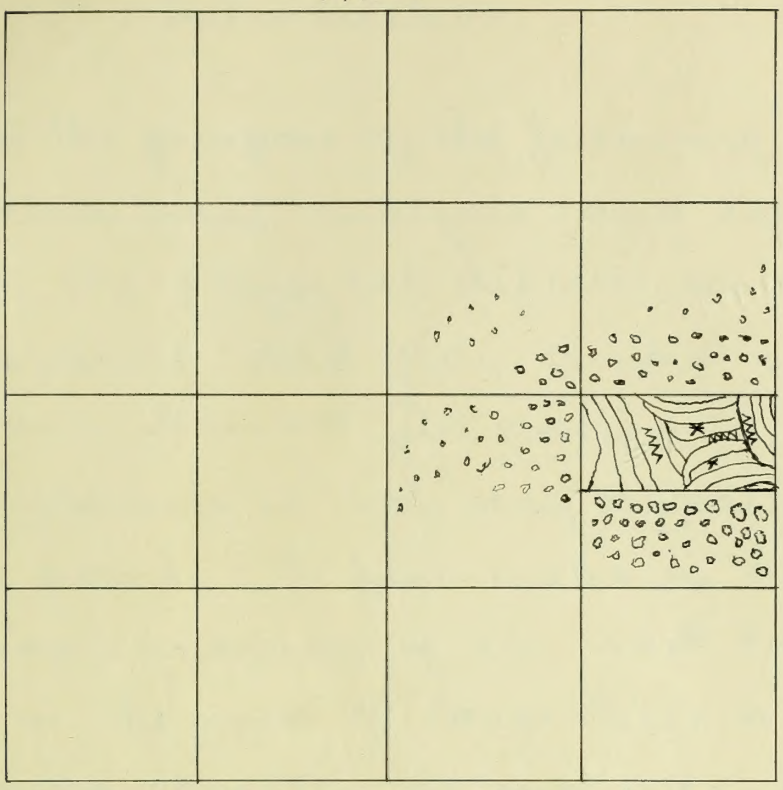
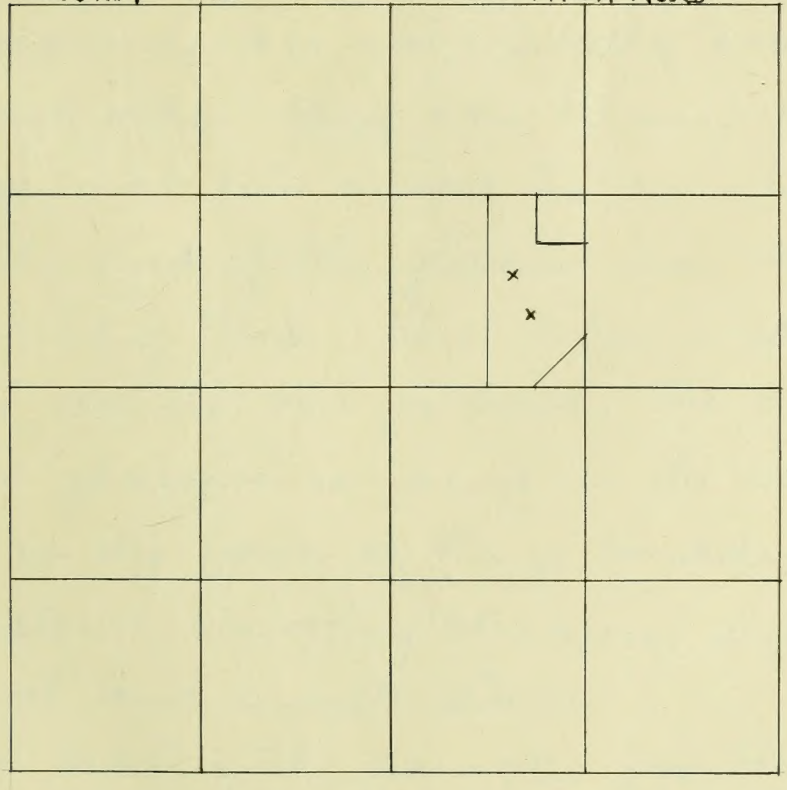
WEST



SOUTH. COUNTY LINE HIGH ROAD NORTH



EAST

× Places where samples were taken.
o Standing Timber.
WW Four areas.

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Introduction.

It is the purpose of the following to show by mechanical analyses and experiments, some of the physical differences between gray prairie and gray timber soils of the Lower Illinois Glaciation. The action of the glaciers is not very apparent just at this point. A few miles in any direction, evidences of its work can be seen, either in the form of large hills or in some cases more correctly as mounds. Although these mounds are not usually connected with each other they can be seen to follow some general line across the country, showing where the end of the glacier was seen for a long period of time. Still other evidences of glacial action but probably the work of earlier glaciers is found in the banks of creeks in the form of huge boulders, and in other slowly moving streams, quantities of gravel and small stones.

In taking the samples for this work the following divisions were made.

The surface samples were taken from the first seven inches; the subsurface from nine to eighteen inches; the first subsoil from twenty to thirty, and the second sub soil from thirty to forty inches. The samples of the timber soil were taken from a twenty acre field lying in the east of Randolph county, and only one half mile west of the experiment field conducted by the Illinois Experimental Station at Cutler Illinois. The field has been cleared only a few years, and timber now stands on both sides and the south end. It has grown only four crops, two of corn and two of wheat.

The prairie samples were taken from the large alleys of the field conducted by the Experiment Station. Previous to its being used for station work, it had been cropped for many years according to the rotation commonly used in that section, which is corn, oats, wheat for one or two years followed by clover. The soils are fairly representative of their types. They are heavier in texture and somewhat lighter in color, than the prairie soils of Central

Illinois. The surface soil of the timber is not so compact, but still is lighter in color than the prairie soil used. In the samples of the subsoil the prairie seems to be, in many places, a darker red and perhaps in some places a little tougher than the Timber. Either of these sub-soils if wet are very sticky and tough while if allowed to dry become very hard. In some borings in the prairie at a depth of from thirty-five to forty inches a stratum of a looser gray soil is found. It is not so tough and crumbles readily, seemingly because the particles are larger and dryer, which may be supposed as the red stratum above it seems almost impervious to water. Some places as seen from wells, the red tough subsoil instead of being above a gray stratum is from six to ten or more feet deep. Beneath that is usually found a hard gray shale-like stratum from three to six feet deep before the rock is found. The depth to the rock varies greatly with-in perhaps only a short distance.

In adjoining prairie fields that have been worked for many years, places that are exposed in the least to surface washing even not over three percent grades have no soil what ever. In these places where the subsoil comes to the surface it apparently becomes more granular and a deeper red, through the oxydation of the iron, and the cementing of the clay particles, by the iron contained in the subsoil.

The field from which the prairie samples were taken is almost level having only a gentle slope to the east. No Tile drainage is used and at times the land becomes very wet because the slope is not sufficient to carry the water away rapidly. The timber field which lies north and south is slightly rolling. A small ditch runs from the center of the east side of the field toward the south west, leaving about one third way from the south end. This gives slight drainage for that lying south of the ditch and for about one half of that lying north of it. At the north end of the field, another ditch

enters the west side about fifty yards from the north end, and coming closer to the end leaves the field near the north east corner. A low area beginning about the center of the divide between these ditches, slopes northward and enters the ditch at that end before it leaves the field. This gives good drainage for the north end of the field, first into this low area and then into the larger ditch.

The samples taken from this field were taken from the divide on the east side of the low area spoken of, and one from the divide on the west side of it. In both cases however they were taken far enough away, and in such positions that they are representative of the higher parts of the field, and from places where no surface washing had occurred.

Table 1.

Real specific gravity of the subsoils.

	Prairie.	Timber.
First sub-soil	2.31	2.42
Second sub-soil	2.34	2.48

The specific gravity of the timber sub-soils is some what greater than that of the prairie. The first and second sub-soils of the prairie differ but slightly. A greater difference is shown in the first and second subsoils of the timber, due to the greater percentage of sand found.

Table 2.

Apparent specific gravity of the samples.

	Prairie		Timber	
	Loose	Compact	Loose	Compact.
Surface.	1.005	1.175	1.015	1.21
Subsurface.	1.04	1.225	1.08	1.295
First subsoil.	1.12	1.33	1.085	1.335
Second subsoil.	1.045	1.23	1.085	1.335

In the apparent specific gravity, the surface soil is some what lower than the other samples. The first subsoil of the prairie in the compact sample shows a greater increase over the other samples. This is probably due to the iron contained in it which caused the clay particles to become cemented together.

Table 3.

Porosity of the sub-soils figured from above.

	Prairie.		Timber.	
	Loose	Compact	Loose	Compact.
First subsoil.	51.52	42.43	55.16	44.99
Second subsoil.	54.77	47.44	55.85	46.17

The porosity as figured from the specific gravities given, shows the first subsoil of the prairie to be lower in both the loose and compact samples. This means that the particles are larger than in the other samples, which gives a greater distance between each particle, but a smaller amount of total space for a given volume of soil. This being the case the water holding capacity of the soil would be decreased, but the rate of percolation of water and air would be increased. This is found in later experiments to be true for the particles being larger, the sample used in the experiments was not so impervious as the other soils used.

Table 4.

Tenacity of the subsoils.

	Prairie.	Timber.
First Subsoil	1.78	4.41
	2.03	4.71
Second Subsoil	4.26	4.35
	5.02	4.33

This shows the weight in grams required to break, with a horizontal pull, an area of the soil one inch square. In the first trial forty & forty five cubic centimeters of water was used in each case, and in the second results given, ten cubic centimeters more water was added to the same soil. Comparatively little difference is shown in any except the first subsoil of the prairie. In this case the soil when wet seemed more granular because a little more sandy, and because of the greater oxydation, which changed the character of the particles. When wet it seemed to be composed of particles of very fine ferruginous sand, which was formed by the cementing action of the iron contained, upon the clay particles.

Table. 5.

Shrinkage of the soil given in inches.

	Prairie	Timber.
Surface.	1/6"	1/6"
Sub-surface.	1/6"	1/6"
First Sub-soil.	1/6"	1/3"
Second Sub-soil.	1/3"	5/12"

The amount of shrinkage was determined by taking crescent shaped moulds four inches long, and mixing the soil with the same amounts of water in each case, and moulding with these forms. When dry they were measured. No difference was found in the surface or sub surface soils of either type. The first sub-soil of the Timber shows just twice as much shrinkage as in the first subsoil of the prairie. The second sub-soil of the Timber shows greater shrinkage than any of the others. This gives an idea of the way a soil will shrink and crack when drying under field conditions. Any cracks caused by this shrinkage will increase the evaporation and also increase percolation. These cracks being

in the sub-soil the evaporation is not of course direct, but the water level is greatly influenced by them. The surface soils showing the least shrinkage is due to the small amount of organic matter contained as well as the absence of a large amount of clay. Where the subsoils come to the surface as is found in many places, the evaporation of the water held in the soil will be very much greater than in the other cases because of its shrinkage and tendency to crack.

Table 6.

Percolation of air.

	Prairie.	Timber.
Surface	500 cc air in 20 min.	500 in 15 min.
Subsurface	" " " 18 "	" " 14 "
First subsoil	" " " 8 "	" " 11 "
Second subsoil.	" " " 10 "	" " 14 "

Soil Tubes were filled with out compacting, and attached to the aspirator, and the time required to draw 500 cubic centimeters of air through it noted.

The surface and sub-surface soils in

The prairie samples seem to be more impervious to the passage of air through them, while the opposite is the case in the subsoils. This difference is due to the gritty, more sand like character of the subsoil particles.

Table 7

Percolation of water.

	Prairie.			Timber.		
	1st 12 hrs.	2nd 12 hrs.	3d 12 hrs.	1st	2nd	3rd.
Surface	30	50	60	27	68	62
Subsurface.	10	38	104	30	68	17
First Subsoil.	none	Trace	4.	15	115	86
Second Subsoil.	none	17	15	Trace	115	48.

This gives the number of cubic centimeters of water caught during each twelve hours of the thirty-six. The rate of percolation in the surface soils is apparently about the same. The subsurface of the Timber shows low for the first twenty four hours and a very great increase after that. This is due to the fact that the tube was found to be defective in the soldering and the increase was obtained by placing a

large funnel under it. This did not give conditions exactly comparable with the others, as the percolation then came from the bottom of the tube. The first subsoil of the timber shows a very low percolation scarcely any being found at the end of thirty six hours. In the same case of the prairie the great difference is probably due to the gritty character of the sample. Almost the same thing is seen in the comparison of the second subsoils as the first. The decrease in the amount of the percolation for the third twelve hours is due to the fact that the soil particles became more compact, because of the water running through it for that length of time, thus giving less space for percolation.

Table 8.

Capillarity in the sub-soils.

	Prairie.		Timber.	
	24 hrs.	48 hrs.	24 -	48.
First Subsoil.	21 3/8"	26 7/8"	14"	19"
Second Subsoil.	9 7/8"	14"	14 1/2"	19 1/4"

A very great difference is seen in the rise of the water during the first twenty-four hours in the prairie sub-soils. Almost one and a half times greater in the first sub-soil. After the first day the rise in the first sub-soil was only about one half greater than the second. The first and second sub-soils of the timber show practically no difference, but when compared with the prairie there is a difference. A rise of over seven inches more in the first sub-soil of the prairie, more than in the timber, and in the second subsoils a decrease of over five inches in the prairie sample.

Granulation or the effect of freezing and thawing was tried on the surface soil, by mixing with it different amounts of organic matter in the proportions of one, two, five and ten percents. These were moulded into [illegible] cubes using as nearly as possible the same amount of water in each case. Those containing the greater percentages of organic matter took the water up more quickly and were in a drier and nicer condition. After the first freezing, large

cracks were found in the check, and also in the cubes containing only one and two per-cents of organic matter. The cracks in the five percent cubes were not so large as in the check, but larger than in the cube con-taining ten percent of organic matter. After thawing the large cracks were kept open exposing a very much greater area for evaporation than in those cubes con-taining five and ten percents of organic matter. After a second freezing the moisture content of the cubes was very much less. The cubes containing only one and two percents of organic matter and also the check cube were beginning to crumble. The cubes containing five and ten percents of organic matter held their shape very well and had only small cracks. After thawing the second time the check and the cubes containing only one and two percents crumbled some and began to break off into small pieces. The cubes containing five and ten percents showed no cracks that were deep enough to cause small pieces to break off. Except

for the small cracks they retained their shape as well as at first. These small cracks show a tendency toward granulation and a breaking up into finer particles which is assisted by the organic matter. The absence of sufficient organic matter to assist in granulation allows the soil to crumble and run together with continued weathering.

Mechanical Analyses.

Surface samples — Timber.

	A.	B.	Av.	A	B	Av.
Loss on ignition	1.90	2.02	1.96	3.12	3.17	3.14
Clay & fine silt	10.40		10.40	13.44	13.68	13.56
Medium silt	15.30		15.30	13.60	11.40	12.50
Coarse silt	24.64		24.64	31.10	26.40	28.70
Fine sand	45.65	43.00	44.32	39.77	42.02	40.89
Medium sand	2.87	2.85	2.86		2.13	2.13
Coarse Sand	.69	.76	.72	.55	.59	.57
Gravel	.16	.11	.13	.10	.26	.18
Total	101.61		100.23	101.58	99.65	100.66

Surface samples - Prairie.

	A.	B.	Av.	A	B.	Av.
Loss on ignition	4.09	4.10	4.09	3.56	3.36	3.46
Clay & fine silt	14.58		14.58	20.88	19.80	20.34
Medium silt	16.08		16.08	13.00	11.52	12.26
Coarse silt	21.96		21.96	26.71	26.55	26.63
Fine sand	38.28	36.60	37.44	31.57	31.90	31.73
medium sand	4.85	4.54	4.69	3.91	4.06	3.98
coarse sand	.82	.80	.81	.81	1.08	.94
gravel	.59	.15	.37	.22	.30	.26
Total	101.25		100.02	101.66	98.57	99.70

Mechanical Analyses.

Sub surface samples – Timber.

	A.	B	Av.	A	B.	Av.
Loss on ignition	2.61	2.30	2.45	2.81	3.01	2.91
Clay & fine silt	17.60	17.60	17.60	21.12	20.40	20.76
medium silt	13.60	9.28	11.44	15.20	16.08	15.64
Coarse silt	27.56	34.11	30.83	32.83	24.14	28.48
Fine sand	36.63	37.04	36.83	26.49	32.47	29.48
medium sand	2.14	1.60	1.87	1.81	2.03	1.92
Coarse sand	.40	.92	.66	.56	.53	.54
Gravel	.22	.09	.15	.35	.18	.26
Total.	100.76	102.93	102.24	101.17	98.84	100.00

Sub. Surface samples – Prairie.

	A.	B.	Av.	A	B	Av
Loss on ignition	2.37	2.39	2.38	3.87	3.77	3.82
Clay & fine silt	18.36	19.20	18.78	24.12	22.80	23.46
medium silt	15.60		15.60	11.28	14.16	12.76
Coarse silt	25.11		25.11	26.28	25.57	25.92
Fine sand	32.00	30.61	31.31	30.64	29.80	30.22
medium sand	5.65	5.36	5.50	3.14	2.49	2.82
Coarse sand	1.67	1.66	1.67	.85	.74	.79
gravel	.45	.53	.49	.18	.51	.34
Total	101.21		100.84	100.36	99.84	100.13.

Mechanical analyses:

First Sub. soil samples Timber.

	A	B	Av.	A.	B	Av.
Loss on ignition	4.14	4.06	4.10	4.36	4.33	4.34
Clay & fine silt	33.60	34.40	34.00	36.40	29.60	32.88
Medium silt	14.16	14.40	14.28	12.10	12.72	12.41
Coarse silt	24.78	25.14	24.96	26.37	27.35	26.86
Fine sand	24.05	21.60	22.82	19.66	22.71	21.28
Medium sand	.88	1.38	1.13	.91	.87	.89
Coarse sand	.26	.32	.29	.15	.12	.13
Gravel	.05	.03	.04	.18		.18
Total.	101.92	101.33	101.62	100.30	97.70	99.76

First Subsoil samples. Prairie.

	A.	B	Av.	A.	B.	Av.
Loss on ignition	3.42	3.58	3.50	5.34	5.01	5.17
Clay & fine silt	20.88	21.24	21.06	32.76	35.60	34.18
Medium silt	12.60	12.80	12.70	11.28	12.24	11.76
Coarse silt	25.78	31.14	28.46	23.80	23.59	23.69
Fine sand	30.20	25.23	27.72	25.74	23.70	24.72
Medium sand	5.19	5.12	5.15	1.04	1.12	1.08
Coarse sand	1.25	1.27	1.26	.25	.29	.27
Gravel	.52	.29	.40	.06		.06
Total	99.84	100.67	100.23	100.27	101.55	100.91

Mechanical Analyses.

Second Sub. soil samples Timber.

	G.	B.	Av.	G.	B	Av.
Loss on ignition	3.04	3.09	3.06	4.44	4.42	4.43
Clay & fine silt		31.40	31.40	29.88	30.21	30.04
Medium silt		14.46	14.46	11.04	10.60	10.82
Coarse silt		23.82	23.82	26.82	22.13	23.97
Fine sand	25.14	24.24	24.69	23.73	23.55	23.64
Medium sand	1.85	1.93	1.89	4.93	5.04	4.48
Coarse sand	.58	.54	.56	.08	1.11	.59
gravel	.15	.15	.15	.002	.48	.24
Total		99.63	100.04	99.92	97.54	98.21

Second Sub. soil Samples Prairie

	G.	B.	Av.	G.	B.	Av.
Loss on ignition	2.41	2.81	2.61	2.58	2.40	2.49
Clay & fine silt	25.60	24.84	25.72	26.84	26.40	26.62
medium silt		13.20	13.20	14.16	13.60	13.85
Coarse silt		28.75	28.75	28.95	26.49	27.77
Fine sand	25.38	25.24	25.36	23.41	31.60	27.50
medium sand	4.79	4.61	4.70	1.65	1.11	1.33
Coarse sand	1.10	.96	.98	.20	.16	.18
gravel	.48	.15	.32		.08	.08
Total		100.56	101.64	97.79	101.84	99.82

Conclusions from Mechanical Analyses.

The surface soil of the prairie gave a greater loss on ignition than the timber surface. because of the greater organic matter contained.

The timber surface contained more sands while the prairie contained more clays.

The subsurface of the timber has more silt and fine sands, while the prairie has a little more clay, and more coarse sands.

The first subsoils contain about the same clay and silts, but the prairie sample contains more sands.

The second subsoil of the timber gives a greater loss on ignition than the prairie.

The timber contains more clay while the prairie contains more silt and fine sand.

The following conclusions on the subsoil are borne out in field work.

The subsoils are more silty and less sandy than the surface samples.

The second subsoils of the timber contain less silt and clay, but much more sand than the first. The first and second subsoils of the prairie are very much alike.

The surface of the timber contains more

sand but less clay and silt than the sub-surface.

The surface of the prairie contains less silt and more fine sand than the sub-surface.

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